Some considerations regarding the proposed NAS study on the "weather enterprise"

The ~~Weather~~ Environmental Prediction Enterprise: A System (& Social) Engineering and Data Science Challenge

1) The term "**Weather**", as indicative of a narrow part of **Earth System Science** and a narrow part of the US programmatic model, often represents a limiting perspective and factor to making progress on **environmental prediction.**

2) The complexity and coupling of the social, programmatic, observation, modeling, analytic and multiple science discipline landscapes within the **environmental prediction enterprise** necessitates a **system engineering** approach to optimize outcomes and limit vulnerabilities.

3) The consideration of the enterprise as a **data flow** problem highlights opportunities and focal points to leverage that could considerably advance the **societal benefits** derived from the **environmental prediction** enterprise.

Presented at the National Academy of Sciences Board on Atmospheric Sciences and Climate meeting Nov 29, 2018
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Jet Propulsion Laboratory
California Institute of Technology

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Operational Environmental Predictions & Products.

The "Global Producing Centers" are responsible for delivering Environmental Prediction (EP) products for:

Present-day –

- *0 days – 15 day leads:* *Short-term atmosphere, ocean, land/hydrology conditions and extremes*
- *2 week – 1 month leads:* *Subseasonal variations of the coupled atmosphere, ocean, land/hydrology, and sea ice conditions and extremes*
- *1 month – 1 year leads:* *Seasonal variations of the coupled atmosphere, ocean (incl. sea level), land/hydrology, and sea ice conditions and extremes*

Within a decade -

- *1 year – 1 decade Leads:* *Annual and interannual variations of the coupled atmosphere, ocean, (incl. sea level), land/hydrology, and sea ice conditions and extremes*
- *The inclusion of atmospheric composition, air quality, and possibly vegetation, components within a number of product suites and lead times above.*

Seamless to 1 Year (soon Decade)

Earth System

Consolidation to major EP Centers

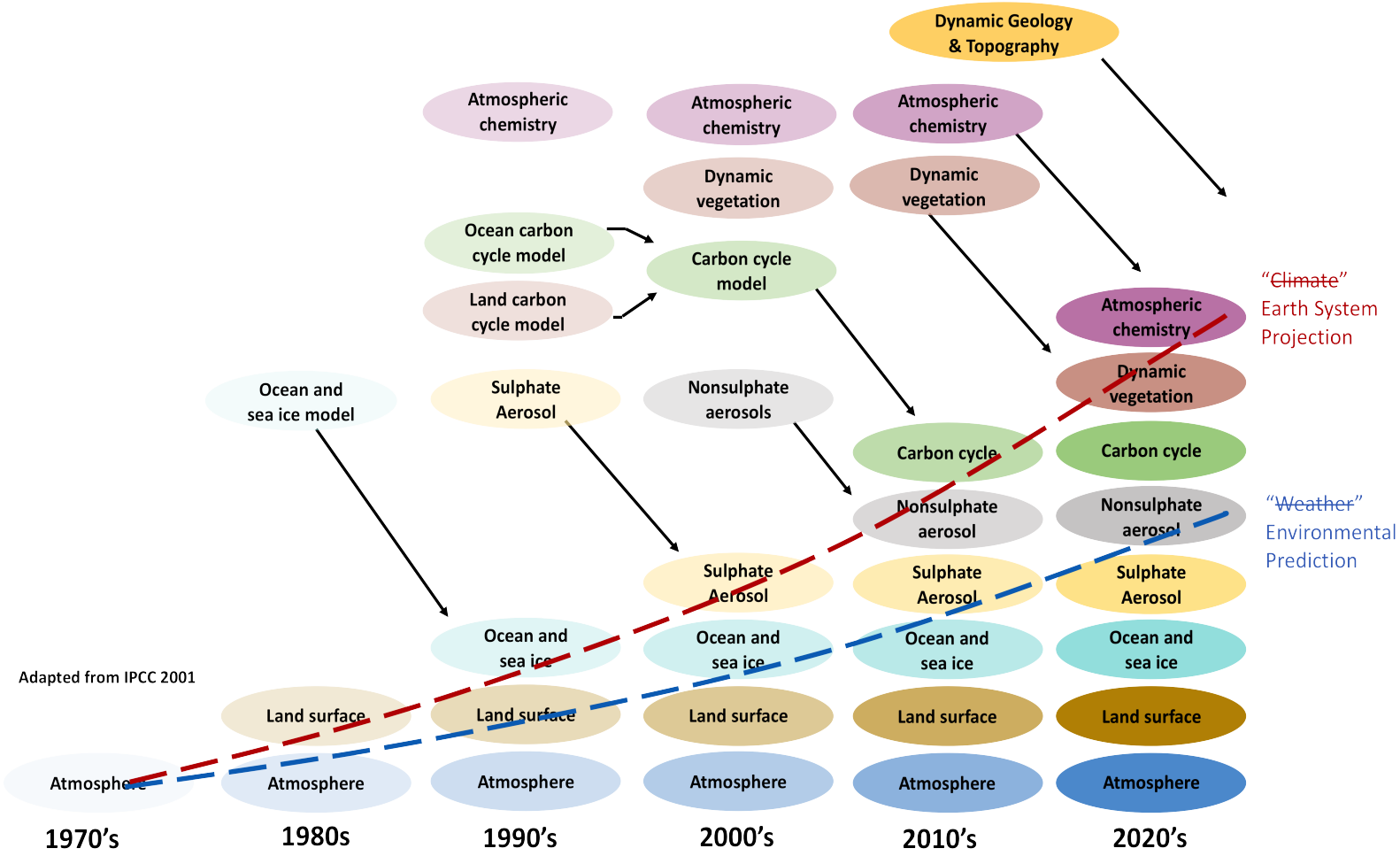
Enabled by international assets and partnerships

These are the **"Implementing Centers"** for operational Environmental Prediction

More than "Weather"

Environmental Prediction & Model Development

The (co-) development path for Earth system and environmental prediction models.



- Today's "~~weather~~" prediction models are more aptly termed "environmental" prediction models.
- The maturing coupled model components of today's Earth System models used for "~~climate~~" projections represent one of the development pathways towards more complex and capable environmental prediction models.

Environmental Prediction Partners & Tasks Matrix

\ Tasks \ Partners \	Identifying & Quantifying Requirements	Observations - Technology Development, Implementation, Acquisition	Model Development & Improvement	Data Assimilation & Environmental Prediction	Product Development, Verification & Dissemination	Basic and Applied Science Research: Physical & Social Science
Global Environmental Prediction Centers (e.g. NCEP, ECMWF, ECCC, JMA, UKMO, etc)		X	XX	XXX	XXX	X
Earth observation agencies (e.g. NASA, ESA, NESDIS, ISRO, JAXA, EUMETSAT)	XX	XXX			XX	XX
International – WMO, IOC, WHO, WFP,	XXX	X	X		X	XX
Other Fed Gov't Agencies & Labs – DoD, NSF, DOE, NASA…	X	XXX	XXX		XX	XXX
State & Local Govt's and Resource Mgmt Agencies	XXX	X			XX	X
Universities		X	XX		X	XXX
Commercial Sector - technology, value added products, decision support	XX	XX		X	XXX	
News/Media – TV/Radio Broadcast, Web Outlets, Phone Apps	X				XX	
Citizens & Communities	XX	X				

Question: What agency/agencies have the purview as well as the capability (i.e. resources, time, expertise) to identify the shortcomings and gaps in this matrix/system, and then develop and implement the needed optimizations and developments?

Environmental Prediction Enterprise

A Data Science And Data Flow Perspective

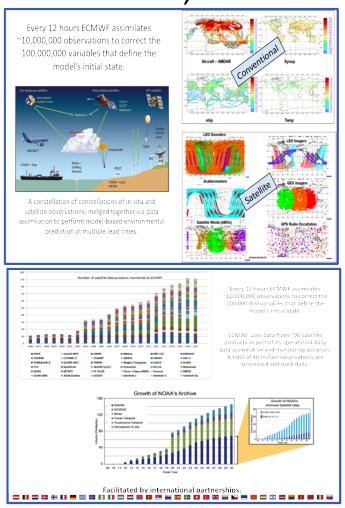
OBSERVATIONS

MODELING & ANALYTIC PIPELINES

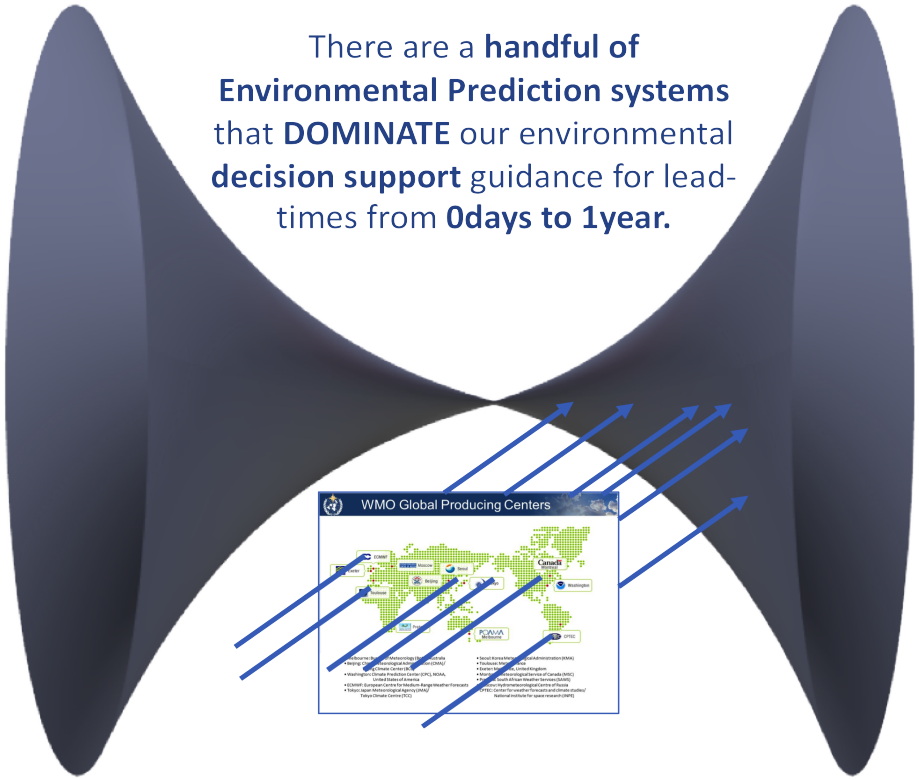
IMPACTS

Order(Billions) → **Order(10)** → **Order(Billions)**

Heterogeneous Types
Real-time
International Sources
Satellite, In-situ



There are a **handful of Environmental Prediction systems** that **DOMINATE** our environmental **decision support** guidance for lead-times from **0days to 1year.**



Billions of personal decisions per day

Try to mitigate **$100'sB per year** in environmental disasters/hazards

Food and water,
Energy production,
Hazard response,
National security,
decision support aiding **O(B) people every day**.

Is this framework efficient and optimized given the IMPACTS?
Does it have vulnerabilities?
Can we see and treat this data flow & modeling "choke point" as an opportunity or focal point?

Summary Remarks

1) The term "**Weather**", as indicative of a narrow part of **Earth System Science** and a narrow part of the US programmatic model, represents a limiting factor to making progress on **environmental prediction.**

2) The complexity and coupling of the social, programmatic, observation, modeling, analytic and science discipline landscapes within the **environmental prediction enterprise** necessitates a **system engineering** approach to optimize outcomes and limit vulnerabilities.

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Another Remark

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International – WMO, IOC, WHO, WFP,	XXX	X	X		X	XX
Other Fed Gov't Agencies & Labs – DoD, NSF, DOE, NASA…	X	XXX	XXX		XX	XXX
State & Local Govt's and Resource Mgmt Agencies	XXX	X			XX	X
Universities		X	XX		X	XXX
Commercial Sector - technology, value added products, decision support	XX	XX		X	XXX	
News/Media – TV/Radio Broadcast, Web Outlets, Phone Apps	X				XX	
Citizens & Communities	XX	X				

Question: What agency/agencies have the purview as well as the capability (i.e. resources, time, expertise) to identify the shortcomings and gaps in this matrix/system, and then develop and implement the needed optimizations and developments?

- NCEP/NOAA is under-resourced to deliver the best possible EPs.
  - Supposition: The US Earth Science committee is not.
- Because of the urgency and near-sightedness of their mission, NCEP/NOAA does have the time, resources or expertise to step back and optimize the overall enterprise with which the EP systems operate. A means, including utilization of the study, should be found to consider this optimization.